

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2022/2023

ERM2136–LINEAR SYSTEMS AND SIGNALS

(All Sections/Groups)

5 OCTOBER 2023
9.00 A.M. – 11.00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of 7 pages including cover page with 5 Questions only.
2. Attempt **ALL** questions. The distribution of the marks for each question is given.
3. Please write **ALL** your answers in the Answer Booklet(s) provided, only answers written in the provided Answer Booklet(s) will be considered for marking purposes.
4. Tables of Laplace Transform pairs and properties are available in Appendices A and B, respectively for your reference.

Question 1

A network is given in **Figure Q1**.

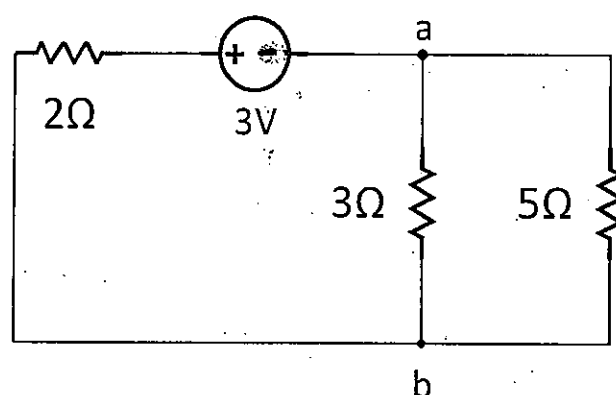


Figure Q1

- (i) Draw a suitable oriented graph with 3 branches to represent the circuit in **Figure Q1** with suitable numbering for each branch. [3 marks]
- (ii) Based on your oriented graph in part (i), obtain the mesh incidence matrix, B . [2 marks]
- (iii) Hence, use mesh analysis technique to find all the branch currents. (Note: You do not need to find the branch voltages). The formulae for mesh analysis are given below:

$$\text{Mesh impedance matrix, } Z_m = BZB^T$$

$$\text{Mesh current, } i_m = Z_m^{-1}B(E - ZI)$$

$$\text{Branch current, } i = B^T i_m$$

where Z is the branch impedance matrix, E is the voltage source matrix, and I is the current source matrix. Superscripts ' T ' and ' -1 ' represent the matrix transpose and inverse operations, respectively.

[11 marks]

Continued...

Question 2

- (a) A signal $f(t)$ is given as follows:

$$f(t) = 2u(t + 3) - u(t - 1) - u(t - 2)$$

Sketch the signal $f(t)$. Determine if $f(t)$ is a continuous or a discrete signal.

[6 marks]

- (b) Two signals are as described below:

$$f_1[n] = \{\dots 0 \ 2 \ 1 \ 6 \ 3 \ 0 \ \dots\}$$

$$f_2[n] = \{\dots 0 \ 1 \ 5 \ 4 \ 7 \ 0 \ \dots\}$$

Perform the convolution of the above signals using the convolution table method. Express the output of the convolution, $y[n]$, in sequence form.

[11 marks]

Question 3

Consider the circuit shown in **Figure Q3**.

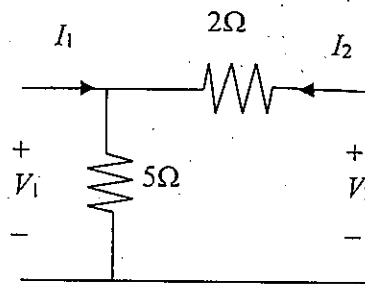


Figure Q3

- (i) Determine the z-parameters of the circuit. Given that:

[12 marks]

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

- (ii) Hence, convert the z-parameters obtained in Q3(i) to y-parameters.

[5 marks]

Continued...

Question 4

- (a) The transfer function of a system is given as:

$$H(s) = \frac{(s + 5)}{s(s + 2)(s - 3)}$$

Draw the pole-zero diagram on the complex s-plane and hence, comment on the system stability. [6 marks]

- (b) Consider a circuit as shown in **Figure Q4(b)**.

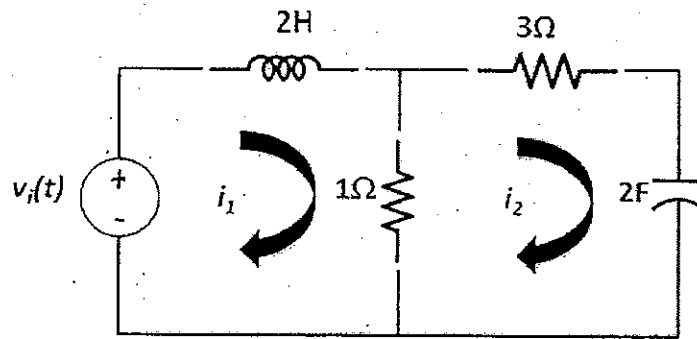


Figure Q4(b)

- (i) Draw the s-domain transformed circuit, assuming zero initial conditions. [4 marks]
- (ii) Hence, obtain the mesh equations. (Note: Not required to solve the equations). [6 marks]
- (c) Determine the transfer function of the electric circuit represented by the following state-equations:

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 2 & -4 \\ 3 & -7 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 3 \\ -1 \end{bmatrix} u(t), \quad y(t) = \begin{bmatrix} -6 & 3 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix}$$

[9 marks]

Continued...

Question 5

- (a) Determine if the following polynomial is Hurwitz. [5 marks]

$$F(s) = s^3 + 2s^2 + 3s + 5$$

- (b) Synthesize an LC network with the impedance function, $Z(s) = \frac{s(s^2+3)(s^2+5)}{(s^2+2)(s^2+4)}$ by using Cauer's 1st form. [14 marks]

- (c) Based on the following specifications, determine the order of a low pass filter by using Butterworth approximation. [6 marks]

Specifications:

Maximum allowable pass band attenuation = 3 dB

Minimum stop band attenuation = 72 dB

Pass band limiting frequency = 15 kHz

Stop band frequency = 60 kHz

Continued...

Appendix A: Table of Laplace Transform Pairs

No.	t -domain function	s -domain transform
1.	$\delta(t)$	1
2.	$u(t)$	$\frac{1}{s}$
3.	$tu(t)$	$\frac{1}{s^2}$
4.	t^n	$\frac{n!}{s^{n+1}}$
5.	e^{-kt}	$\frac{1}{s+k}$
6.	$t^n e^{-kt}$	$\frac{n!}{(s+k)^{n+1}}$
7.	$\sin \omega t$	$\frac{\omega}{s^2 + \omega^2}$
8.	$\cos \omega t$	$\frac{s}{s^2 + \omega^2}$
9.	$e^{-kt} \sin \omega t$	$\frac{\omega}{(s+k)^2 + \omega^2}$
10.	$e^{-kt} \cos \omega t$	$\frac{s+k}{(s+k)^2 + \omega^2}$
11.	$t \sin \omega t$	$\frac{2\omega s}{(s^2 + \omega^2)^2}$
12.	$\sinh \beta t$	$\frac{\beta}{s^2 - \beta^2}$
13.	$\cosh \beta t$	$\frac{s}{s^2 - \beta^2}$
14.	$\sin(\omega t + \phi)$	$\frac{s \sin \phi + \omega \cos \phi}{s^2 + \omega^2}$
15.	$2 k e^{-\sigma t} \cos(\omega t - \phi)$, where $k = k \angle \phi$	$\frac{k}{s + \sigma + j\omega} + \frac{k^*}{s + \sigma - j\omega}$
16.	$f(t)$ periodic with period T	$\frac{1}{1 - e^{-Ts}} \int_0^T f(t) e^{-st} dt$

Continued...

Appendix B: Table of Laplace Transform Properties

Operations	$f(t)$	$F(s)$
1. Multiplication by scalar	$kf(t)$	$kF(s)$
2. Scaling	$f(kt), k \geq 0$	$\frac{1}{k} F\left(\frac{s}{k}\right)$
3. Addition and subtraction	$f_1(t) \pm f_2(t)$	$F_1(s) \pm F_2(s)$
4. Time shift	$f(t-t_0)u(t-t_0)$	$F(s)e^{-st_0}$
5. Frequency shift	$f(t)e^{\alpha t}$	$F(s-\alpha)$
6. Time differentiation	$\frac{df(t)}{dt}$	$sF(s) - f(0)$
	$\frac{d^2 f(t)}{dt^2}$	$s^2 F(s) - sf(0) - f'(0)$
7. Time integration	$\int_0^t f(\tau) d\tau$	$\frac{1}{s} F(s)$
8. Initial value	$\lim_{t \rightarrow 0} f(t)$	$\lim_{s \rightarrow \infty} sF(s)$
9. Final value	$\lim_{t \rightarrow \infty} f(t)$	$\lim_{s \rightarrow 0} sF(s)$
10. Frequency differentiation	$tf(t)$	$-\frac{dF(s)}{ds}$
11. Frequency integration	$\frac{f(t)}{t}$	$\int_s^\infty F(\bar{s}) d\bar{s}$
12. Convolution	$f_1(t) * f_2(t)$	$F_1(s)F_2(s)$

End of Paper.